

1 What is claimed is:

2 1. A substrate for an ion-exchange system structure, said substrate comprising a  
3 surface wherein at least a portion of the surface is irradiated by a laser radiation to enlarge  
4 a reactive surface area.

5 2. The substrate of claim 1, wherein the portion of the surface is irradiated by  
6 exposing the surface to the laser radiation near an ablation threshold of the membrane.

7 3. The substrate of claim 1, wherein the portion of the surface is irradiated by  
8 melting, boiling, or quenching part of the surface with laser radiation.

9 4. The substrate of claim 1, wherein the laser irradiated surface is coated with a layer  
10 of conductive material.

11 5. The substrate of claim 4, wherein the conductive material is a metal or an alloy.

12 6. The substrate of claim 4, wherein the layer of conductive material is further coated  
13 with a continuous or discontinuous layer of catalytic material.

14 7. The substrate of claim 6, wherein the catalytic material is selected from a group  
15 consisting of Pt, Pt alloys, V, V alloys, titanium dioxide, iron, nickel, lithium and gold.

16 8. The substrate of claim 1, wherein the laser irradiated surface is coated with a  
17 continuous or discontinuous layer of catalytic material.

18 9. The substrate of claim 8, wherein the catalytic material is selected from a group  
19 consisting of Pt, Pt alloys, V, V alloys, titanium dioxide, iron, nickel, lithium and gold.

20 10. The substrate of claim 8, further comprising micro openings wherein a fuel flows  
21 through the micro openings to reach the catalytic material.

22 11. An ion exchange membrane with an enlarged reactive surface, said membrane is  
23 produced by:

24 providing a laser roughened surface;

25 covering the laser roughened surface with a solution;

26 allowing the solution to solidify to form an ion exchange membrane; and

27 separating the ion exchange membrane from the laser roughened surface,

28 wherein said ion exchange membrane has an enlarged reactive surface that is a  
29 negative replica of the laser roughened surface.

30 12. The ion exchange membrane of claim 11, wherein the solution comprises an  
31 electrolyte and a solvent.

32 13. The ion exchange membrane of claim 12, wherein the electrolyte is selected from  
33 a group consisting of sulfonated ion-conducting aromatic polymer, phosphonated ion-  
34 conducting aromatic polymer, carboxylated ion-conducting aromatic polymer and

1 perfluorinated co-polymer, and wherein the solvent is selected from a group consisting of  
2 lower aliphatic alcohols, water, and a mixture thereof.

3 14. The ion exchange membrane of claim 11, wherein the enlarged reactive surface is  
4 further coated with a layer of conductive material.

5 15. The ion exchange membrane of claim 14, wherein the conductive material is a  
6 metal or an alloy.

7 16. The ion exchange membrane of claim 14, wherein the enlarged reactive surface is  
8 further coated with a continuous or discontinuous layer of catalytic material.

9 17. The ion exchange membrane of claim 16, wherein the catalytic material is  
10 selected from a group consisting of Pt, Pt alloys, V, V alloys, titanium dioxide, iron,  
11 nickel, lithium and gold.

12 18. An ion exchange membrane with an enlarged reactive surface, said ion exchange  
13 membrane is produced by :

14 providing an ion exchange membrane;

15 providing a laser roughened surface;

16 stamping the ion exchange membrane with the laser roughened surface; and

17 separating the ion exchange membrane from the laser roughened surface,

18 wherein the stamped ion exchange membrane has an enlarged reactive surface that  
19 is a negative replica of the laser roughened surface.

20 19. An ion exchange membrane with enlarged reactive surfaces on a front side and a  
21 back side, said ion exchange membrane is produced by:

22 \ providing a mold having an inner upper surface and an inner lower surface;

23 \ filling the mold with a solution;

24 allowing the solution to solidify to form an ion exchange membrane; and

25 separating the ion exchange membrane from the mold,

26 wherein the inner upper surface and inner lower surface of the mold are  
27 roughened by laser irradiation, and wherein said ion exchange membrane has an upper  
28 surface that is a negative replica of the inner upper surface of the mold and a lower  
29 surface that is a negative replica of the inner lower surface of the mold.

30 20. A fuel cell assembly comprising:

31 an anode;

32 a cathode;

33 an electrolyte connecting the anode and the cathode; and

34 a fuel,

1 wherein said anode comprises an ion exchange surface enlarged by laser radiation.

2 21. The fuel cell assembly of claim 20, wherein the ion exchange surface is coated by  
3 a layer of conductive material and a layer of catalytic material.

4 22. The fuel cell assembly of claim 21, wherein the layer of catalytic material is a  
5 discontinuous layer.

6 23. The fuel cell assembly of claim 21, wherein the conductive material is a metal or  
7 an alloy, and wherein the catalytic material is selected from a group consisting of Pt and  
8 Pt alloys.

9 24. The fuel cell assembly of claim 20, wherein the electrolyte is a liquid electrolyte.

10 25. The fuel cell assembly of claim 21, wherein the electrolyte is a PEM, and wherein  
11 said anode contains micro openings so that the fuel can flow through the micro openings  
12 to reach the catalytic material on the ion exchange surface .

13 26. The fuel cell assembly of claim 20, wherein said cathode comprises an ion  
14 exchange surface enlarged by laser radiation.

15 27. A fuel cell assembly comprising:

16 a fuel; and

17 a PEM-electrode structure comprising a PEM,

18 wherein said PEM is produced by one of :

19 (a) solidifying a solution on a laser roughened surface;

20 (b) solidifying a solution in a mold with a laser roughened inner surface; or

21 (c) stamping an ion-exchange membrane with a laser roughened surface.

22 28. The fuel cell assembly of claim 27, wherein the PEM-electrode structure further  
23 comprise a layer of conductive material and a layer of catalytic material.

24 29. The fuel cell assembly of claim 28, wherein the conductive material is a metal or  
25 an alloy, and wherein the catalytic material is selected from a group consisting of Pt and  
26 Pt alloys.

27 30. A method for producing an ion exchange membrane with a roughened surface,  
28 comprising:

29 providing a laser roughened surface;

30 covering the laser roughened surface with a solution;

31 allowing the solution to solidify to form an ion exchange membrane; and

32 separating the ion exchange membrane from the laser roughened surface, said ion  
33 exchange membrane having a roughened surface that is a negative replica of the laser  
34 roughened surface.

1 31. The method of claim 30, wherein the solution comprises a electrolyte material and  
2 a solvent.

3 32. The method of claim 31, wherein the electrolyte is selected from a group  
4 consisting of sulfonated ion-conducting aromatic polymer, phosphonated ion-conducting  
5 aromatic polymer, carboxylated ion-conducting aromatic polymer and perfluorinated co-  
6 polymer, and wherein the solvent is selected from a group consisting of lower aliphatic  
7 alcohols, water, and a mixture thereof.

8 33. A method for producing a ion exchange membrane with a roughened surface,  
9 comprising:

10 providing a mold having an inner upper surface and an inner lower surface;

11 filling the mold with a solution;

12 allowing the solution to solidify to form an ion exchange membrane; and

13 separating the ion exchange membrane from the mold,

14 wherein the inner upper surface and inner lower surface of the mold are

15 roughened by laser irradiation, and wherein said ion exchange membrane has an upper

16 surface that is a negative replica of the inner upper surface of the mold and a lower

17 surface that is a negative replica of the inner lower surface of the mold.

18 34. The method of claim 33, wherein the solution comprises a electrolyte material and  
19 a solvent.

20 35. The method of claim 34, wherein the electrolyte is selected from a group  
21 consisting of sulfonated ion-conducting aromatic polymer, phosphonated ion-conducting  
22 aromatic polymer, carboxylated ion-conducting aromatic polymer and perfluorinated co-  
23 polymer, and wherein the solvent is selected from a group consisting of lower aliphatic  
24 alcohols, water, and a mixture thereof.

25 36. A method for producing a ion exchange membrane with a roughened surface,  
26 comprising:

27 providing an ion exchange membrane;

28 providing a laser roughened surface;

29 stamping the ion exchange membrane with the laser roughened surface; and

30 separating the ion exchange membrane from the laser roughened surface,

31 wherein the stamped ion exchange membrane has a roughened surface that is a  
32 negative replica of the laser roughened surface.

33 37. A method for roughening a surface of an ion exchange system structure with laser  
34 radiation, comprising:

1 providing an ion exchange system structure;  
 2 providing a source of laser radiation; and  
 3 irradiating a surface of the ion exchange system structure with laser radiation to  
 4 create a roughened surface that increases reactive exchange area of said surface.

5 38. The method of claim 37, further comprising:  
 6 depositing a laser shading material on the surface of the ion exchange system  
 7 structure, near the surface of the ion exchange system structure , or in the volume of the  
 8 ion exchange system structure before laser radiation.

9 39. The method of claim 37, wherein the source of laser radiation is a pulse laser.

10 40. The method of claim 39, wherein in the pulse laser is a NeYAG laser or an  
 11 excimer laser.

12 41. The method of claim 37, wherein the laser radiation is provided through a mask to  
 13 generate shaded areas on the surface of the ion exchange system structure.

14 42. The method of claim 37, wherein the laser radiation produces a diffracted image.

15 43. The method of claim 37, wherein the ion exchange system structure is made of  
 16 polymers, ceramics, or silicates.

17 44. The method of claim 37, wherein the surface of ion exchange system structure is  
 18 irradiated with laser radiation near an ablation threshold of a material being irradiated.

19 45. The method of claim 37, wherein the surface of the ion exchange system structure  
 20 is irradiated with laser radiation to melt, boil and quench part of the surface.

21 46. A method for roughening a surface of an ion exchange system structure with laser  
 22 radiation, comprising:

23 providing an ion exchange system structure;  
 24 providing a source of laser radiation; and  
 25 irradiating a surface of the ion exchange system structure with laser radiation to  
 26 create a roughened surface that increases a reactive surface area of said surface,  
 27 wherein the ion exchange system structure is made of a polymer or a silicate, the  
 28 source of laser radiation is a pulse excimer laser or a NeYAG laser, and the roughened  
 29 surface is created either by irradiating the surface of the ion exchange system structure  
 30 with laser radiation near an ablation threshold of a surface material, or by irradiating the  
 31 surface of the ion exchange system structure with laser radiation to melt, boil and quench  
 32 part of the surface.